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Production Pathways and Separation Procedures for High-Diagnostic-Value Activation Species, Fission Products, and Actinides Required for Preparation of Realistic Synthetic Post-Detonation Nuclear Debris:

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Status Report and FY16 Project Plan

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Project Goal: The objective of this project is to provide a comprehensive study on the production routes and chemical separation requirements for activation products, fission products, and actinides required for the creation of realistic post-detonation surrogate debris. Isotopes that have been prioritized by debris diagnosticians will be examined for their ability to be produced at existing irradiation sources, production rates, and availability of target materials, and chemical separation procedures required to rapidly remove the products from the bulk target matrix for subsequent addition into synthetic debris samples. The characteristics and implications of the irradiation facilities on the isotopes of interest will be addressed in addition to a summary of the isotopes that are already regularly produced.

Project Outline: The following list gives the topic areas that are being researched in order to provide the final report detailing facilities, production pathways, and chemical separations required to produce the isotopes of interest for post-synthetic debris samples. Research includes discussions with personnel who are currently involved in the post-detonation synthetic debris program, lists of prioritized isotopes from the debris diagnosticians, and searches of available literature on production and separation methods. The projected completion date for each of the topic areas is also provided.

Topic Area	Projected Completion
I. Define current capabilities	12/2015

- a. Identify nuclides used in previous lab challenge and round robin exercises including activation products, fission products, and actinides
  - i. Identify production routes or material inventory for each nuclide
  - ii. Detail separation methods when applicable
- b. Identify nuclides planned for future exercises
  - i. List of facilities currently used for isotope production and production routes
  - ii. Detail post-production separation procedures
  - iii. Identify challenges with current production route/separation procedures that could be addressed with alternative methods (to be investigated in Part II)
- c. Commercially available nuclides
  - i. Obtain quotes for cost including purity, amount of carrier, and chemical form

II. Identify future needs and means for isotope production	09/2016

a. Nuclide needs for future exercises based on needs of debris diagnostics and device modeling – create a list of prioritized isotopes not previously produced for/used in exercises
    i. Activation Products
        1. Investigate charged-particle reactions as a production route
        2. Focus on materials associated with device components and urban rubble
        3. Examine facilities such as U.C. Davis and LBNL cyclotrons and identify additional light- and heavy-ion irradiation facilities
        4. Begin with elements produced at U.C. Davis, including W, Pb, Pt, Ir, Au, Fe, and components of steel
    ii. Actinides
        1. Examine production of shorter-lived actinides through reactor irradiation or radiochemical milking
        2. Include isotopes of U, Pu, Am, and Np
    iii. Fission Products
        1. Production of fission products using a wide range of neutron energies in addition to thermal
        2. Identify enhanced production routes for wing and valley products
        3. Include fission products routinely used for spectral analysis, including Tb-161, Eu-156, Zr-95, Cs-137, and Te-132
b. Production pathways – identify ideal facility for each nuclide to be produced based on facility requirements
c. Once production pathways are identified investigate necessary separation procedures to obtain purified samples of the nuclide of interest (this can be done in parallel with b. above but will require the most time to complete)
    i. If procedures are not readily available in the literature, they will have to be developed in the laboratory using tracer materials – this may delay completion of this part depending on availability of materials

III. Compile characteristics of potential isotope production facilities 03/2016
a. General facility requirements – this will be worked in parallel with II. above but cannot be completed until the list of nuclides in II. has been completely identified.
    i. Method of production
    ii. Neutron flux and energy range
    iii. Cost
    iv. Quantity of material permitted
    v. Type of materials needed
    vi. Delivery time and shipping capabilities
    vii. Scheduling
    viii. Beam type and intensity
b. List of facilities to be researched
    i. Dense Plasma Focus (DPF) at NNSS

ii. National Criticality Experiments Research Center (NCERC) at NNSS
iii. U.C. Davis Crocker Lab Cyclotron
iv. McClellan Nuclear Research Center – TRIGA reactor
v. ORNL High Flux Irradiation Facility (HFIR)
vi. Spallation Neutron Source (ORNL)
vii. Los Alamos Neutron Science Center (LANSCE)
viii. Missouri University Research Reactor (MURR)
ix. Center of Accelerator Mass Spectrometry (CAMS at LLNL)
x. National Ignition Facility (NIF at LLNL)
xi. MIT Reactor
xii. 88-Inch Cyloctron (LBNL)
xiii. Penn State Research Reactor
xiv. USGS Reactor
xv. U.C. Irvine research reactor
xvi. Cyclotron Institute (TAMU)
xvii. Advanced Test Reactor (INL)
xviii. Oregon State University research reactor
xix. Edwards Accelerator Lab (Ohio University)